RZLINE code modeling of Sn laser-produced plasma sources of EUV radiation

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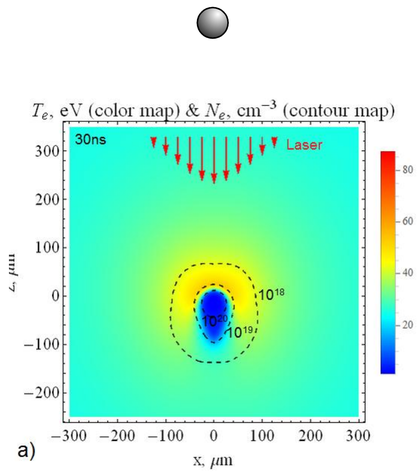
Introduction

- In search of ideal target for LPP EUV source the prepulsed (preconditioned) targets seem to be the best candidate for limited mass approach at the moment.
- Whilst the target type is more or less determined, the prepulse and main pulse parameters are still under investigation.
- We concentrate this poster on detailed analysis of evaporation process by main pulse of two types of targets – tin droplet and preconditioned tin target, represented by solid pancake or dense mist.

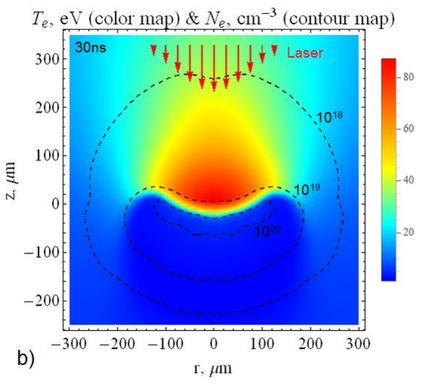
Setup of numerical experiment

- RZLINE RHD code is used for simulations.
- Targets:
  - Tin droplet 30 um in diameter;
  - Tin disk of 300 um in diameter (0.2 um thickness), made from 30 um droplet;
  - Tin mist of 1 um fragments, 300 um in diameter and 3 um height.
- Main pulse:
  - CO_2, 300 um focal spot ($1/e^2$), variable power, variable duration, gaussian spatial profile, rectangular time profile.

Droplet

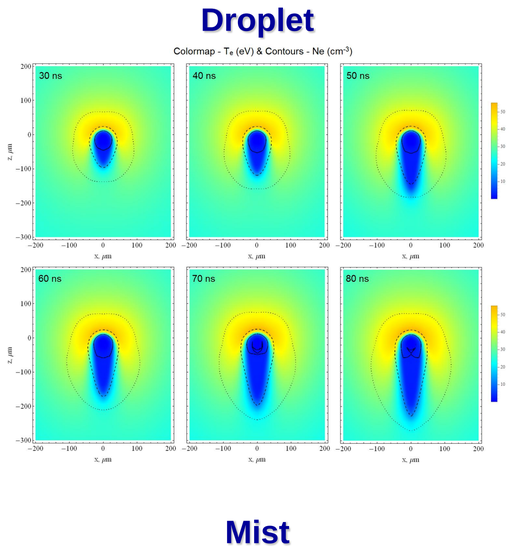


Pancake / Mist



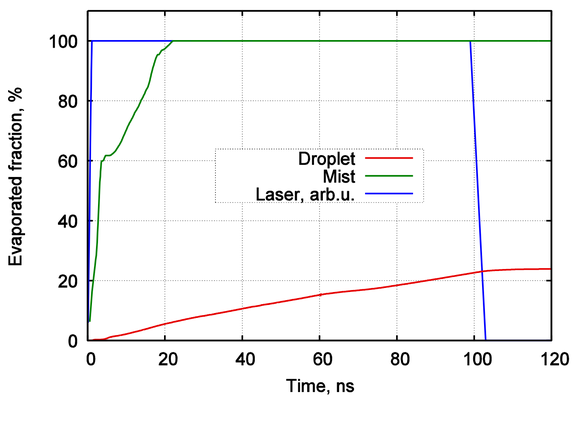
Simulation results

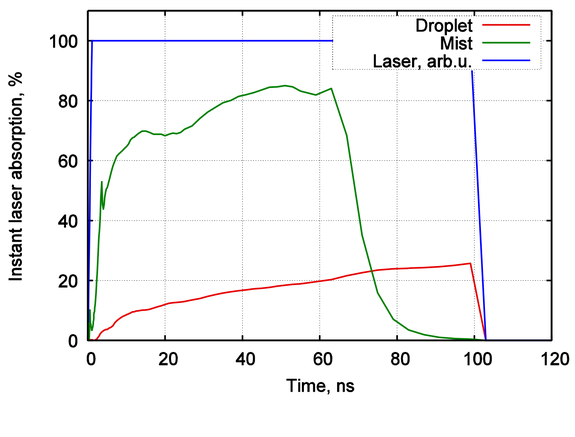
Droplet

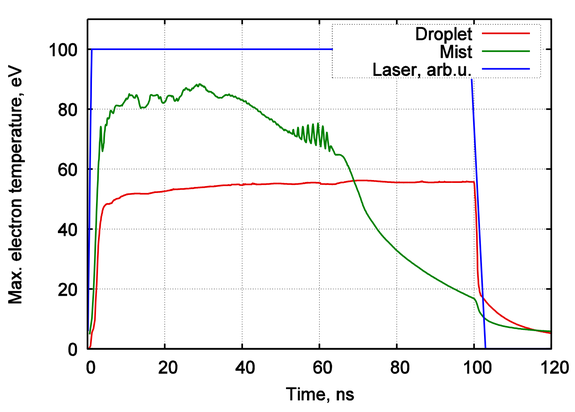


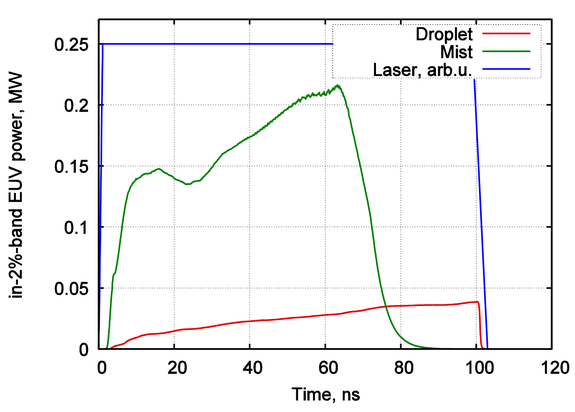
Mist

- Steady target evaporation in case of solid droplet leads to linear-close-to-const time profile of radiative and energetic properties of the source, constant anisotropy of EUV.
- But due to incapability of main CO_2 laser pulse to be focused into spots less then ~200 um in diameter, and various defects of it spatial profile, most of the laser energy miss the target.
- Unlike the solid droplet, pancake targets provide more dynamics during evaporation process, absorbing more laser energy, which leads to total evaporation of the target, much higher CE and less debris.
- Unsteady characteristics of the source, the duration of the laser pulse needs to be adjusted to prevent passing through a burnt out target. Tilted disks are also a problem, which arises after defocused prepulse leading to instability of EUV radiation anisotropy.

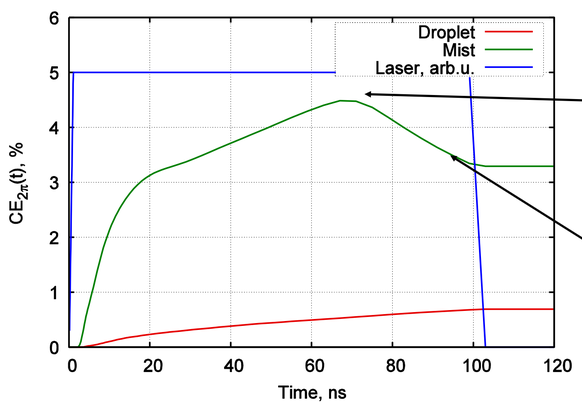




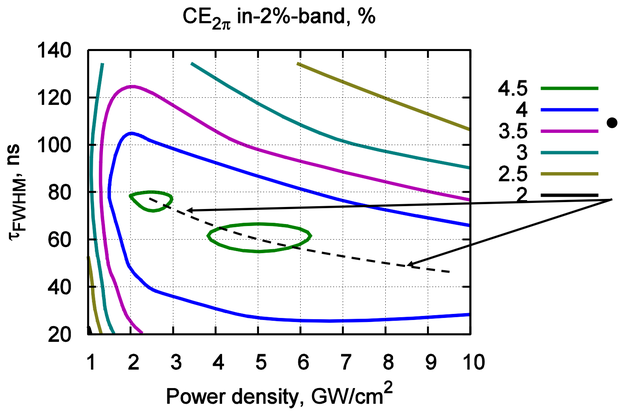




Optimization of the main pulse duration



- At this point the plasma reaches both optimal density and geometrical shape.
- Declination of CE shows, that the target worked out all its mass and has been burnt out → the rest of main laser pulse passes through without absorption.



- Optimal pulse duration depends on pulses power density (energy and focal spot).

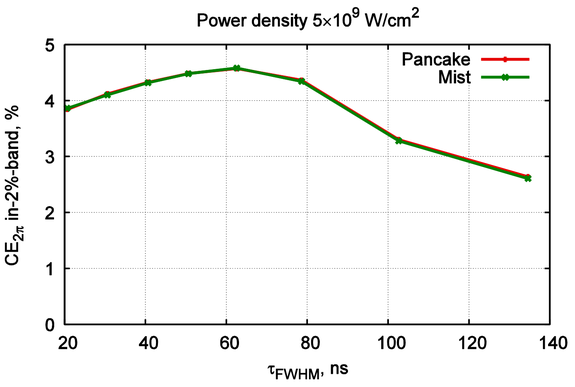
Pancake vs. Mist

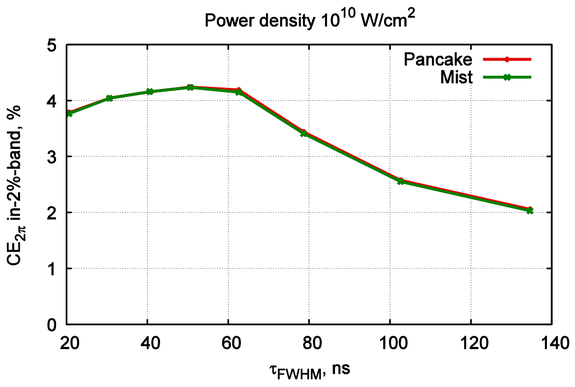
30 um in diameter tin droplet

Pancake
- 300 um in diameter;
- 0.2 um thickness.

Mist
- 300 um in diameter;
- 3 um thickness;
- ~1 um in diameter tin fragments.

- Both representations of preconditioned target seem to give very similar integral characteristics of LPP EUV source, including CE.
- Time resolved characteristics also proved to be alike.





Conclusions

- Three types of targets have been investigated – solid tin droplet, pancake and mist.
- The preconditioned targets provide more effective utilization of laser energy although the latter requires optimization for a concrete mass of the target to minimize losses of energy due to burnouts of the targets.
- Two variations of preconditioned targets – pancake and mist – seem to be quite similar in terms of CE, ions energy, etc.

References

- Koshelev et al., J. Micro/Nanolith. MEMS MOEMS 11(2), 021112 (2012)

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